List of All WARSSS Flowcharts in this File (single-page printable)

p. 2 Flowchart 1: WARSSS Main Phases

p. 3 Flowchart 2: WARSSS Main Phases with Summary Descriptions

p. 4 Flowchart 3: WARSSS Complete Phases and Steps Master Flowchart, Detailed Version

p. 5 Flowchart 4: WARSSS Reconnaissance Level Assessment (RLA) Phase (hot-linked steps version of this flowchart is available online)

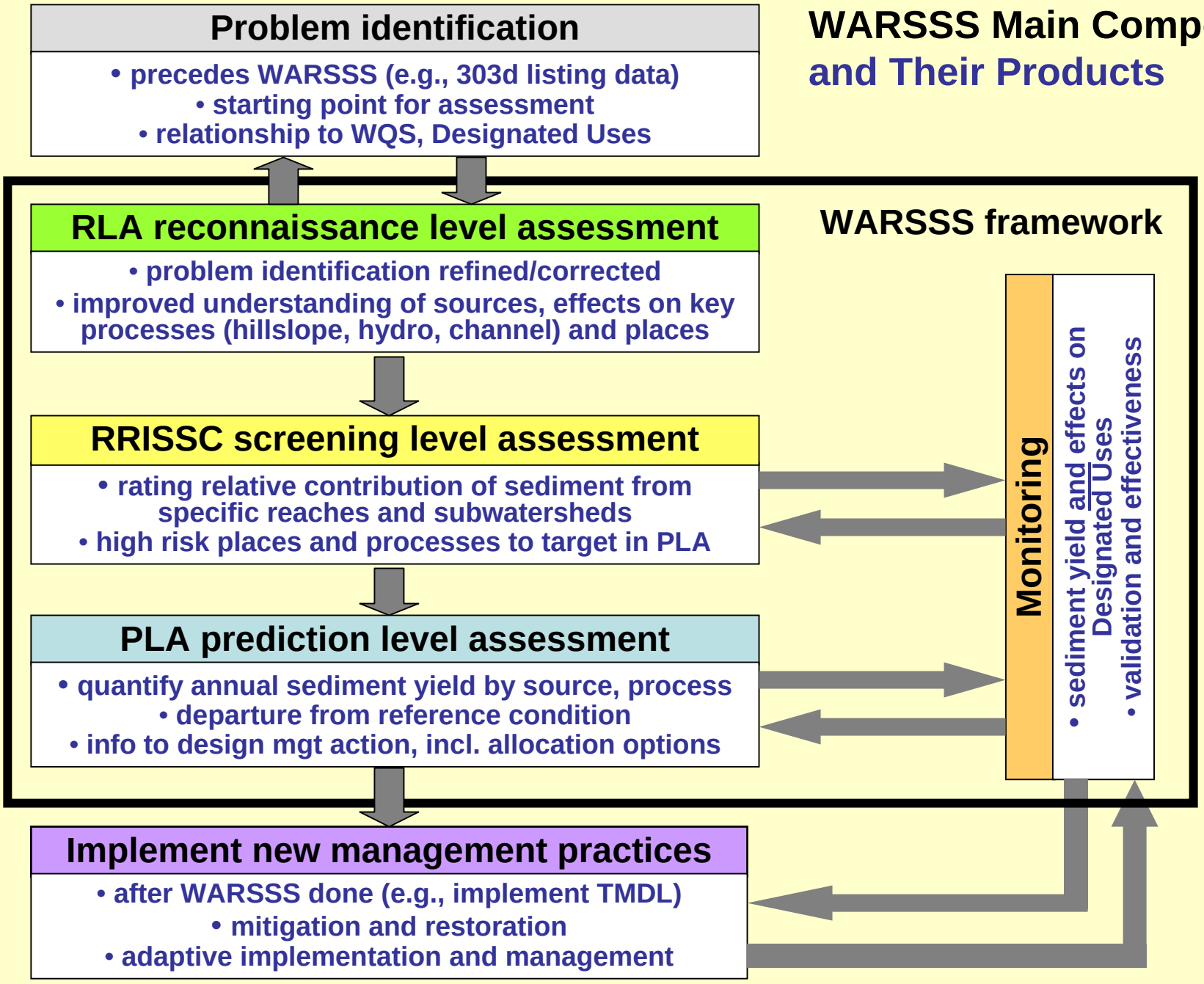
p. 6 Flowchart 5: WARSSS Rapid Resource Inventory for Sediment and Stability Consequence (RRISSC) Phase, Summary Version (hot-linked steps version of this flowchart is available online)

p. 7 Flowchart 6: WARSSS Rapid Resource Inventory for Sediment and Stability Consequence (RRISSC) Phase Flowchart, Detailed Version

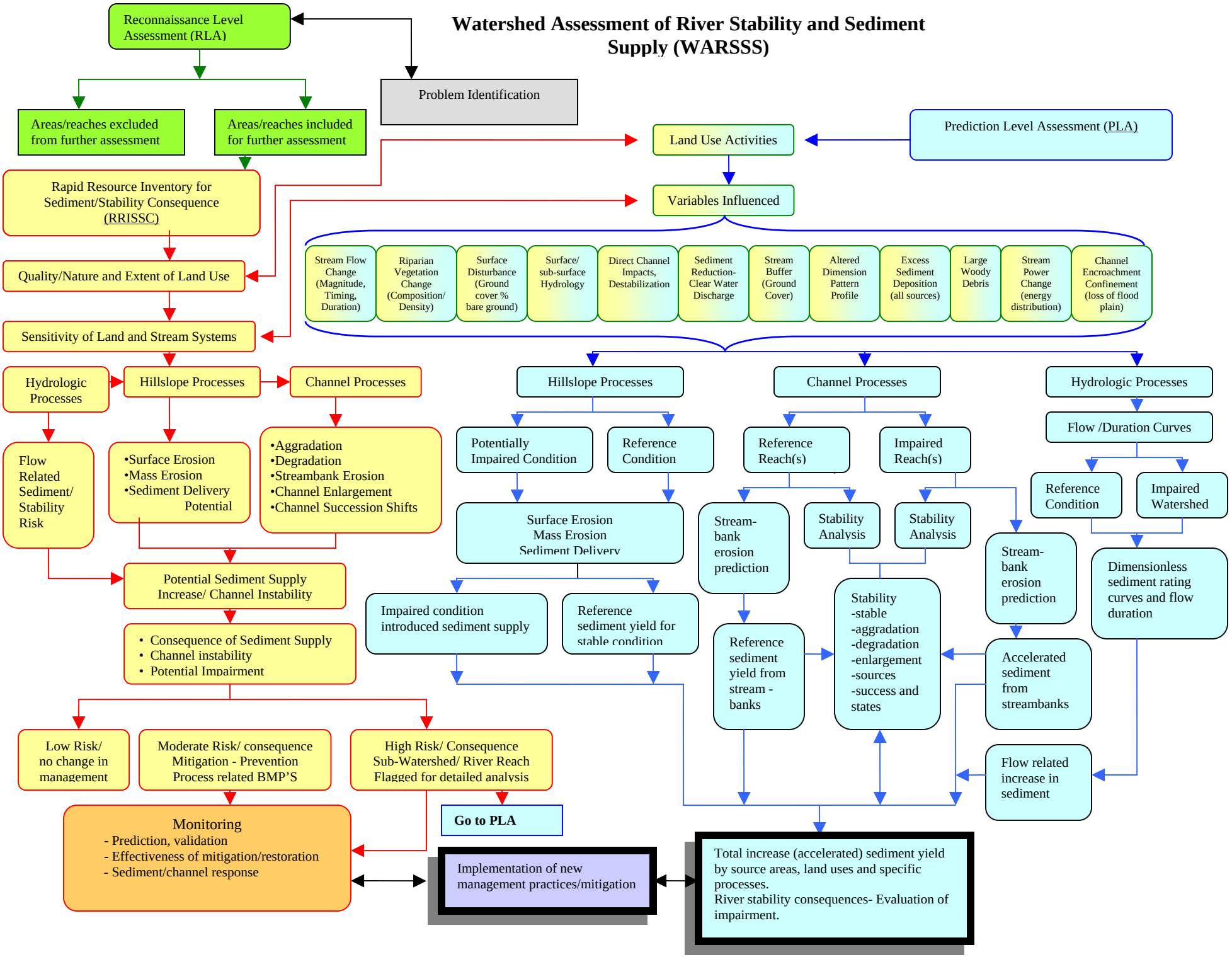
p. 8 Flowchart 7: WARSSS Prediction Level Assessment (PLA) Phase Flowchart, Summary Version (hot-linked steps version of this flowchart is available online)

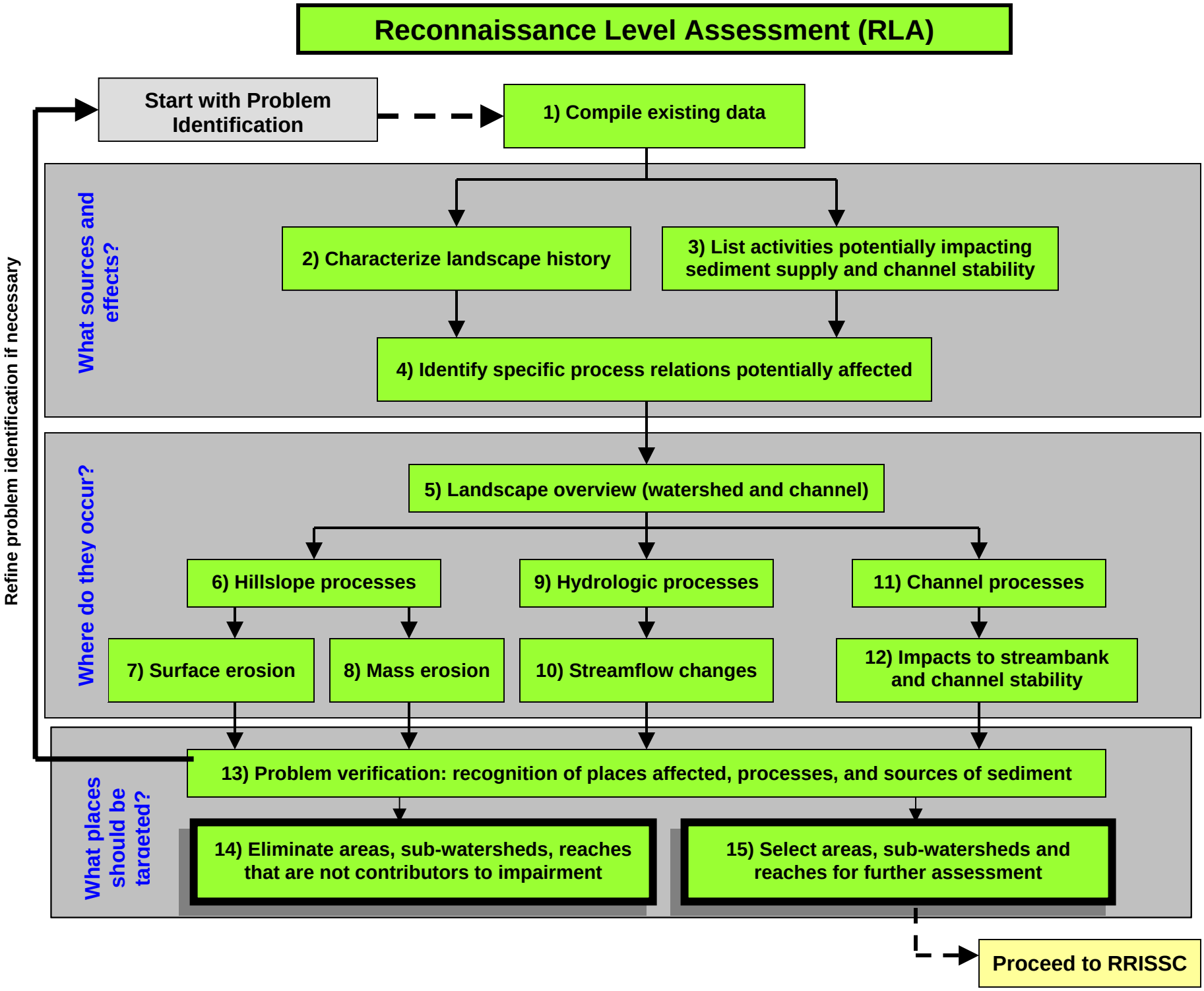
p. 9 Flowchart 8: WARSSS Prediction Level Assessment (PLA) Phase Flowchart, Detailed Version

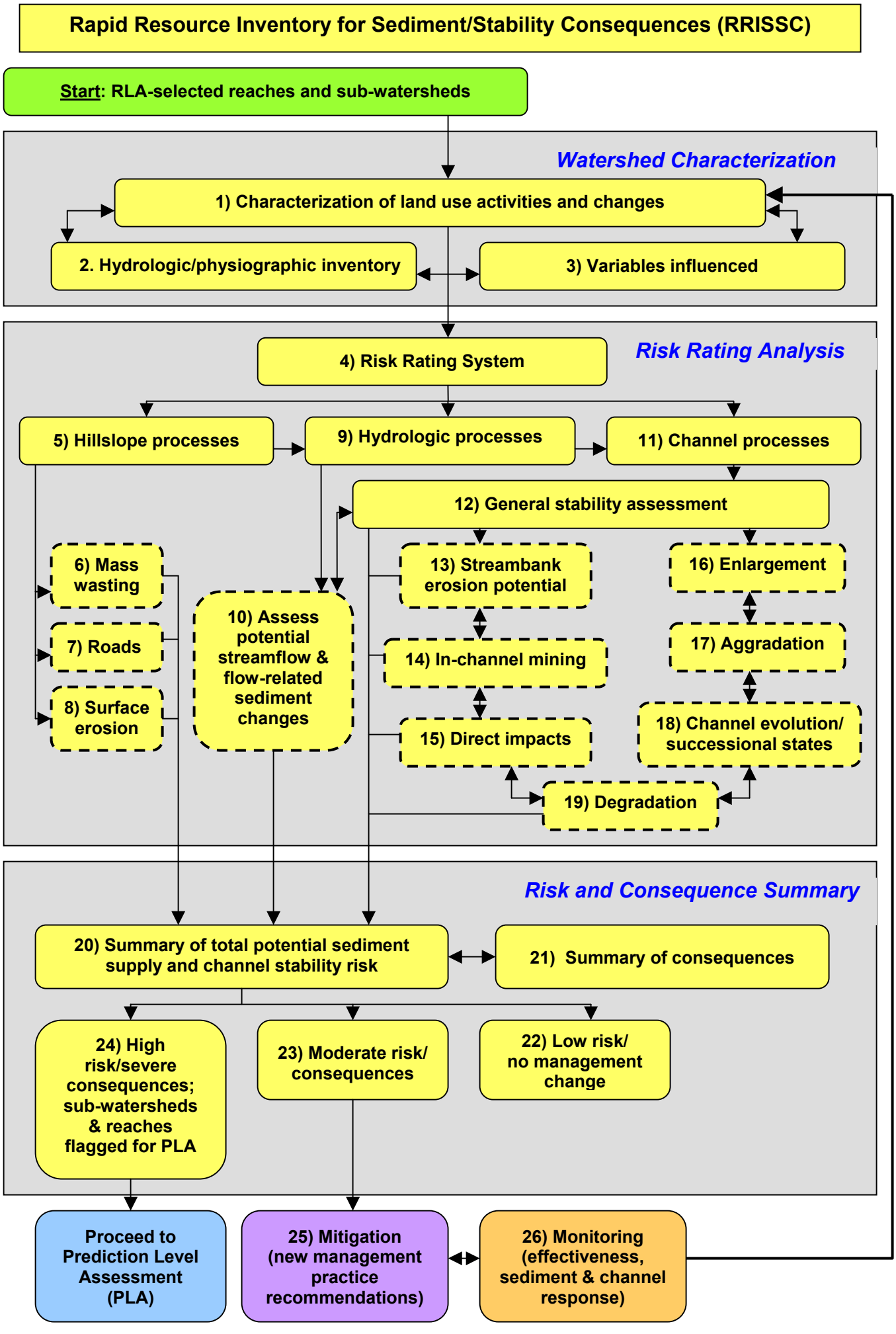
WARSSS Main Components and Their Products

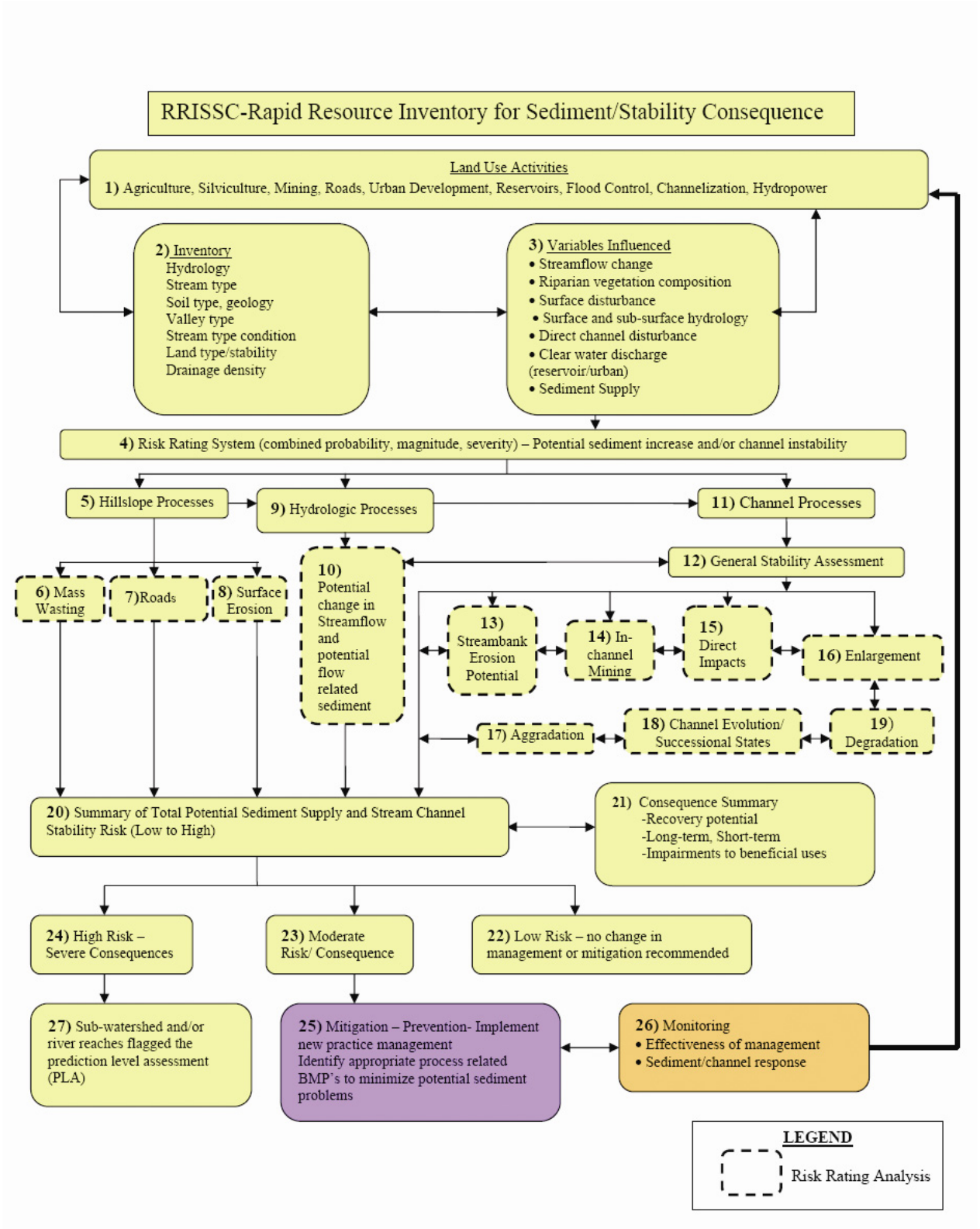


Watershed Assessment of River Stability and Sediment Supply (WARSSS)




Reconnaissance Level Assessment (RLA)
Start with Problem Identification
1) Compile existing data
What sources and effects?
2) Characterize landscape history
3) List activities potentially impacting sediment supply and channel stability
4) Identify specific process relations potentially affected
Where do they occur?
5) Landscape overview (watershed and channel)
6) Hillslope processes
9) Hydrologic processes
11) Channel processes
7) Surface erosion
8) Mass erosion
10) Streamflow changes
12) Impacts to streambank and channel stability
What places should be targeted?
13) Problem verification: recognition of places affected, processes, and sources of sediment
14) Eliminate areas, sub-watersheds, reaches that are not contributors to impairment
15) Select areas, sub-watersheds and reaches for further assessment
Proceed to RRISSC
Refine problem identification if necessary


Rapid Resource Inventory for Sediment/Stability Consequences (RRISSC)
Start: RLA-selected reaches and sub-watersheds
Watershed Characterization
1) Characterization of land use activities and changes
2. Hydrologic/physiographic inventory
3) Variables influenced
Risk Rating Analysis
4) Risk Rating System
5) Hillslope processes
9) Hydrologic processes
11) Channel processes
12) General stability assessment
6) Mass wasting
7) Roads
8) Surface erosion
10) Assess potential streamflow & flow-related sediment changes
13) Streambank erosion potential
14) In-channel mining
15) Direct impacts
16) Enlargement
17) Aggradation
18) Channel evolution/ successional states
19) Degradation
Risk and Consequence Summary
20) Summary of total potential sediment supply and channel stability risk
21) Summary of consequences
24) High risk/severe consequences; sub-watersheds & reaches flagged for PLA
23) Moderate risk/ consequences
22) Low risk/ no management change
Proceed to Prediction Level Assessment (PLA)
25) Mitigation (new management practice recommendations)
26) Monitoring (effectiveness, sediment & channel response)


RRISSC-Rapid Resource Inventory for Sediment/Stability Consequence
Land Use Activities
1) Agriculture, Silviculture, Mining, Roads, Urban Development, Reservoirs, Flood Control, Channelization, Hydropower
2) Inventory
Hydrology
Stream type
Soil type, geology
Valley type
Stream type condition
Land type/stability
Drainage density
3) Variables Influenced
• Streamflow change
• Riparian vegetation composition
• Surface disturbance
• Surface and sub-surface hydrology
• Direct channel disturbance
• Clear water discharge (reservoir/urban)
• Sediment Supply
4) Risk Rating System (combined probability, magnitude, severity) – Potential sediment increase and/or channel instability
5) Hillslope Processes
9) Hydrologic Processes
11) Channel Processes
12) General Stability Assessment
6) Mass Wasting
7)Roads
8) Surface Erosion
10) Potential change in Streamflow and potential flow related sediment
13) Streambank Erosion Potential
14) In-channel Mining
15) Direct Impacts
16) Enlargement
17) Aggradation
18) Channel Evolution/ Successional States
19) Degradation
20) Summary of Total Potential Sediment Supply and Stream Channel Stability Risk (Low to High)
21) Consequence Summary
-Recovery potential
-Long-term, Short-term
-Impairments to beneficial uses
24) High Risk – Severe Consequences
23) Moderate Risk/ Consequence
22) Low Risk – no change in management or mitigation recommended
27) Sub-watershed and/or river reaches flagged the prediction level assessment (PLA)
25) Mitigation – Prevention- Implement new practice management
Identify appropriate process related BMP's to minimize potential sediment problems
26) Monitoring
• Effectiveness of management
• Sediment/channel response
LEGEND
Risk Rating Analysis

Prediction Level Assessment (PLA)

Start: Sub-watersheds & streams at high/v. high risk from RRISSC phase

Hydrologic relations

1. USGS regional curves
2. Drainage area
3. Field calibration of bankfull discharge, cross-sectional area
4. Final determination of bankfull discharge, bankfull dimension

Stream morphology

5. Stream classification
6. Detailed morphological relations: dimensionless ratios

Stability analysis

7. Channel stability analysis
8. Bank erosion prediction (BEHI, NBS)
9. Output: streambank erosion rates, tons/yr

Flow/sediment relations

10. Flow modification
11. Dimensionless flow duration curves
12. Measure bankfull Q, susp. sediment, bedload
15. Convert to dimensional flow duration curve

Sediment rating curves

13. Ref dimensionless sediment, bedload rating curves
14. Convert to dimensional susp sediment, bedload rating curve
16. Calculate sediment yield for baseline existing condition: flow related sediment yield
17. Output: flow-related increase above baseline

Channel & sediment supply changes from hillslope, channel & hydrologic processes

18. Changed channel characteristics
19. Bedload transport (stream power)
22. Sed. transport changes, excess power and/or sediment
20. Hillslope processes (introduced sed. supply)
21. Output: introduced hillslope sediment

Stream stability consequences summary

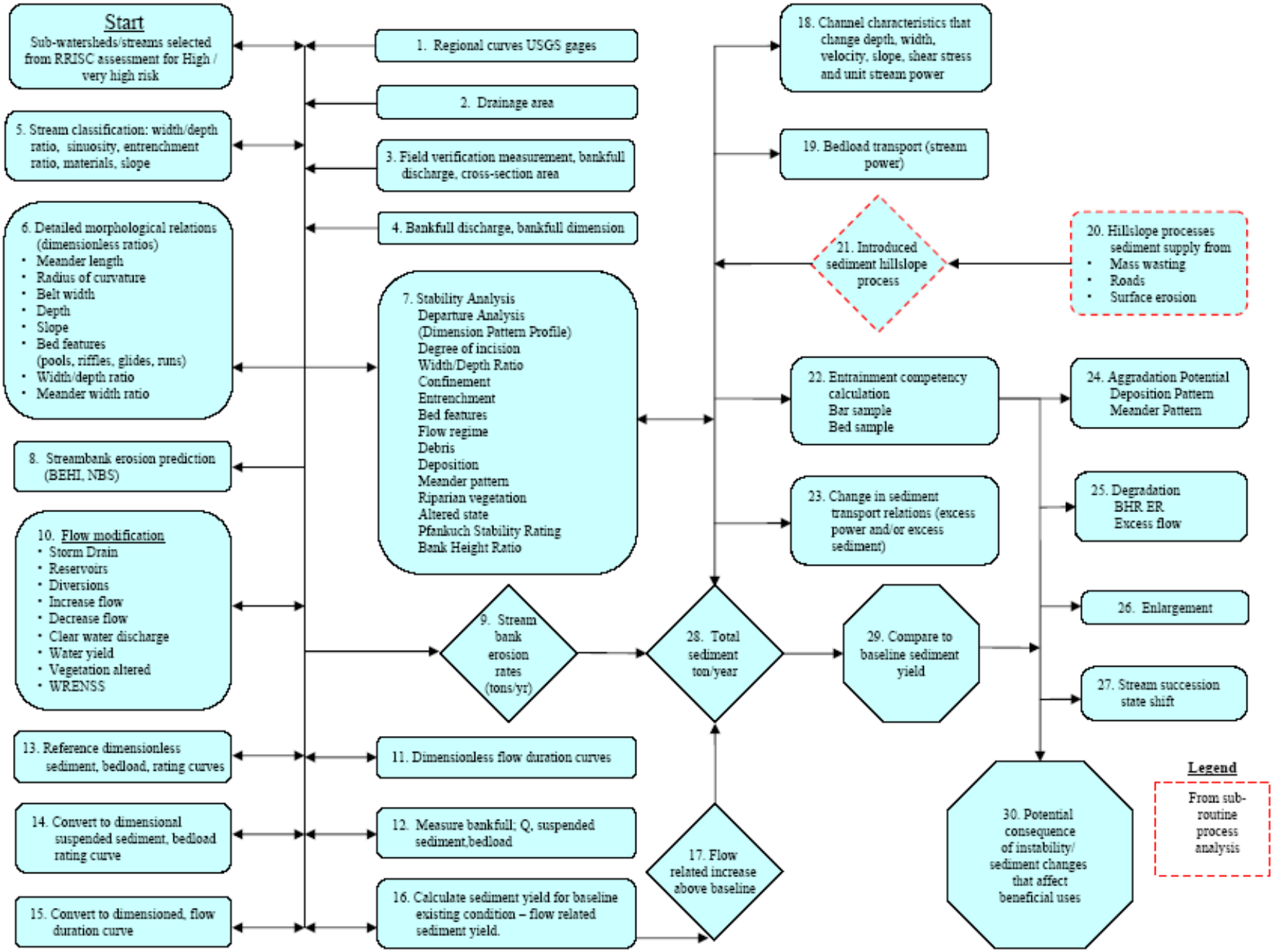
23. Entrainment competency calculation: bar, bed samples
25. Degradation
27. Stream succession state shift
24. Aggradation potential deposition & meander patterns
26. Enlargement

Summary analysis

28. Output: total sediment summary tons/yr
29. Departure analysis: compare to baseline sediment yield
30. ID disproportionate sediment loads and/or stability effects by land use category

Effectiveness and validation monitoring

Interpretation of all analyses for potential consequences of instability/sediment changes that affect beneficial uses: revised management direction, mitigation, restoration


Start
Sub-watersheds/streams selected from RRISC assessment for High / very high risk
1. Regional curves USGS gages
2. Drainage area
3. Field verification measurement, bankfull discharge, cross-section area
4. Bankfull discharge, bankfull dimension
5. Stream classification: width/depth ratio, sinuosity, entrenchment ratio, materials, slope
6. Detailed morphological relations (dimensionless ratios)
• Meander length
• Radius of curvature
• Belt width
• Depth
• Slope
• Bed features (pools, riffles, glides, runs)
• Width/depth ratio
• Meander width ratio
7. Stability Analysis
Departure Analysis
(Dimension Pattern Profile)
Degree of incision
Width/Depth Ratio
Confinement
Entrenchment
Bed features
Flow regime
Debris
Deposition
Meander pattern
Riparian vegetation
Altered state
Pfankuch Stability Rating
Bank Height Ratio
8. Streambank erosion prediction (BEHI, NBS)
10. Flow modification
• Storm Drain
• Reservoirs
• Diversions
• Increase flow
• Decrease flow
• Clear water discharge
• Water yield
• Vegetation altered
• WRENSS
9. Stream bank erosion rates (tons/yr)
11. Dimensionless flow duration curves
12. Measure bankfull; Q, suspended sediment,bedload
13. Reference dimensionless sediment, bedload, rating curves
14. Convert to dimensional suspended sediment, bedload rating curve
15. Convert to dimensioned, flow duration curve
16. Calculate sediment yield for baseline existing condition – flow related sediment yield.
17. Flow related increase above baseline
18. Channel characteristics that change depth, width, velocity, slope, shear stress and unit stream power
19. Bedload transport (stream power)
20. Hillslope processes sediment supply from
• Mass wasting
• Roads
• Surface erosion
21. Introduced sediment hillslope process
22. Entrainment competency calculation
Bar sample
Bed sample
23. Change in sediment transport relations (excess power and/or excess sediment)
28. Total sediment ton/year
29. Compare to baseline sediment yield
24. Aggradation Potential
Deposition Pattern
Meander Pattern
25. Degradation
BHR ER
Excess flow
26. Enlargement
27. Stream succession state shift
30. Potential consequence of instability/ sediment changes that affect beneficial uses
Legend
From sub-routine process analysis